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BACKLIGHT UNIT AND LIQUID CRYSTAL DISPLAY APPARATUS COMPRISING THE SAME

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION:

The present invention relates to a backlight unit for irradiating a liquid crystal or the like with light from the rear side thereof, and a liquid crystal display apparatus comprising the backlight unit.

2. DESCRIPTION OF THE RELATED ART:

In general, a liquid crystal display apparatus comprises a liquid crystal panel comprising a pair of opposed substrates, between which a liquid crystal layer is sandwiched. In the liquid crystal display apparatus, a display voltage is applied to the liquid crystal layer by an electrode provided on each of the pair of opposed substrates. In the liquid crystal display apparatus, by changing the orientations of liquid crystal molecules within the liquid crystal layer, light incident to the liquid crystal layer is transmitted/blocked so as to display characters, graphics or the like on the display screen.

A backlight unit is provided at the rear side of the liquid crystal panel. The backlight unit comprises

a light source and a light guide plate. Light is input from the light source to an end side of the light guide plate. The input light is propagated through the light guide plate and is output through a broader side (proximal to the liquid crystal panel) of the light guide plate. The backlight unit allows light output by the light guide plate to impinge on the liquid crystal panel.

Hereinafter, the configuration of a liquid crystal display apparatus comprising a conventional backlight unit will be described.

Figure **7** shows the configuration of the major parts of a conventional liquid crystal display apparatus **200**.

The liquid crystal display apparatus **200** comprises a liquid crystal panel **101** used as a screen display and a backlight unit **110** provided at the rear side of the liquid crystal panel **101**. The backlight unit **110** irradiates the liquid crystal panel **101** with light.

The backlight unit **110** comprises a linear light source **111**, a lamp reflector **112**, a frame-like chassis **113** made of a resin, a reflection sheet **114**, a light guide

plate **115**, a diffuse sheet **116**, a condenser sheet **117**, and a diffuse sheet **118** having a light blocking function.

The chassis **113** houses a plurality of members included in the backlight unit **110** and holds the liquid crystal panel **101**. One end portion of the chassis **113** is folded into a "U" shape (or a squared C shape). The linear light source **111** is housed within the folded portion (a concave portion of the folded portion). The linear light source **111** is a fluorescent lamp elongating in a direction or an LED. The chassis **113** is provided with the lamp reflector **112**. The lamp reflector **112** is provided in a manner to surround the linear light source **111**. Both the chassis **113** and the lamp reflector **112** are in a "U" shape (or a squared C shape) so that the lamp reflector **112** has an opening through which light emitted by the linear light source **111** goes out.

The reflection sheet **114** and the light guide plate **115** are provided on the chassis **113**. Optical sheets, such as the diffuse sheet **116**, the condenser sheet **117**, the diffuse sheet **118** having a light blocking function, and the like, are provided on the light guide plate **115**. The light guide plate **115** is in the shape of a wedge, through

one end side of which light is input from the linear light source **111** positioned along the width direction thereof. Light input through the end side of light guide plate **115** is propagated through the light guide plate **115** toward the other end side. In this case, light going toward the rear side of the light guide plate **115**, on which the reflection sheet **114** is provided, is reflected by the reflection sheet **114** toward the front side of the light guide plate **115**, on which the liquid crystal panel is provided, so that the light is emitted through the light guide plate **115**. In order to emit light uniformly, a plurality of optical sheets (e.g., the diffuse sheet **116**, the condenser sheet **117**, and the diffuse sheet **118**) are provided on the rear side of the liquid crystal panel **101**. A lamp cover is attached to a predetermined portion of the chassis **113**.

On the backlight unit **110**, the liquid crystal panel **101** on which a circuit board and the like are mounted is provided. A metal frame **120** is provided to fix the liquid crystal panel **101** on a predetermined position of the chassis **113**.

Recently, while some transmissive liquid crystal

display apparatuses are made thinner and thinner and smaller and smaller, the size of the liquid crystal panel included in other transmissive liquid crystal display apparatuses is increasing. In the above-described transmissive liquid crystal display apparatus **200**, characters, graphics, or the like are displayed by irradiating the liquid crystal panel **101** with light from the backlight unit **110** provided at the rear side of the liquid crystal panel **101**. In order to increase the size of the liquid crystal panel, it is necessary to attach the liquid crystal panel **101** to the backlight unit **110** while keeping the display area of the liquid crystal panel **101** large. Therefore, the width or area of the surrounding portion (frame portion) of the liquid crystal panel **101** needs to be reduced (narrow the frame).

In a liquid crystal display apparatus comprising an edge light type backlight unit, a bright line occurs at the light source side of the liquid crystal panel **101**, so that irregularity occurs in the luminance distribution of the liquid crystal panel **101**. This is because, for example, a large amount of light is input to the light source side of the crystal panel **101**, or light emitted by the light source **110** is directly input to the liquid

crystal panel **101**. Note that the edge light type backlight unit is a backlight unit in which a linear light source (e.g., a fluorescent lamp) is provided along an end side of a light guide plate.

When the frame of the liquid crystal display apparatus is narrowed, the distance between the liquid crystal panel **101** and the light source (e.g., a fluorescent lamp) is reduced. In this case, a liquid crystal display apparatus comprising an edge light type backlight unit is strongly affected by light emitted by the linear light source. In addition, the liquid crystal panel is adversely affected by electromagnetic noise generated by the linear light source (e.g., flicker in the screen). Electromagnetic noise is an example of ElectroMagnetic Interference (EMI).

Japanese Laid-Open Publication No. 62-169193 discloses a method of covering the surface of an incandescent lamp with an irradiation reducing means made of an Indium Tin Oxide (ITO) film so as to absorb infra-red light to reduce the influence of heat. In this method, however, 20% of the visible light emitted by the lamp is absorbed by the ITO film, resulting in a reduction in the

utilization efficiency of light. Further, a thicker ITO film is more effective in the enhancement of the capability of the film to absorb electromagnetic noise. However, the thicker the ITO film, the lesser the transmittance of light.

Japanese Utility Model Laid-Open Publication No. 5-69733 and Japanese Laid-Open Publication No. 2002-148651 disclose a method of using a transparent conductive material to reduce an adverse influence of electromagnetic noise generated by a fluorescent lamp on a liquid crystal panel. In this method, however, the transparent conductive material covers the liquid crystal panel, so that 20% of light emitted by the light source is absorbed by the transparent conductive material, resulting in a reduction in the transmittance of light.

Further, Japanese Laid-Open Publication No. 11-142841, Japanese Laid-Open Publication No. 11-224517, and Japanese Laid-Open Publication No. 2001-126522 disclose a method of reducing the adverse influence of electromagnetic noise generated by a fluorescent lamp on a liquid crystal panel by providing a reflection sheet comprising a conductive film, a metal

lamp reflector, or the like. However, the adverse influence of electromagnetic noise generated by a fluorescent lamp on a liquid crystal panel is not sufficiently reduced by the method.

SUMMARY OF THE INVENTION

According to an aspect of the present invention, a backlight unit is provided, which comprises: a linear light source for generating a light source light; a light guide plate comprising an end side and a broad side; and a light amount reducing member for reducing the amount of the light source light, capable of transmitting light and made of a material having a greater attenuation coefficient than that of the light guide plate. The light source light is input to the end side, is propagated through the light guide plate, and is output through the broad side. The light amount reducing member is provided at a joint portion of the end side and the broad side and portions neighboring the joint portion of the light guide plate.

In one embodiment of this invention, the light amount reducing member is in the shape of an "L" extending

from the end side to the broad side.

In one embodiment of this invention, the light amount reducing member is made of a conductive material.

In one embodiment of this invention, the light amount reducing member is connected to a ground.

According to another aspect of the present invention, a liquid crystal display apparatus is provided, which comprises a backlight unit comprising: a linear light source for generating a light source light; a light guide plate comprising an end side and a broad side; and a member for reducing the amount of the light source light, capable of transmitting light and made of a material having a greater attenuation coefficient than that of the light guide plate. The light source light is input to the end side, is propagated through the light guide plate, and is output through the broad side. The light amount reducing member is provided at a joint portion of the end side and the broad side and portions neighboring the joint portion of the light guide plate. The apparatus further comprises a liquid crystal panel provided on the broad side of the backlight unit, capable of performing liquid crystal

display using the light source light of the backlight unit.

Hereinafter, functions of the present invention will be described.

When light is propagated through a medium, the behavior of the light is greatly affected by the refractive index (n) of the medium and the attenuation coefficient (k) of the medium. The relationship between a complex refractive index (N) and the refractive index (n) and attenuation coefficient (k) of the medium is represented by:

$$N = n - jk.$$

Figure 6 shows an example of the behavior of light in a medium. As shown in the top and middle of Figure 6, light travels slower in a medium having a refractive index (n) than in vacuum. As shown in the bottom of Figure 6, the intensity of light traveling in a medium having a complex refractive index of (n-jk) is attenuated with an increase in the attenuation coefficient (k) of a medium. Therefore, a medium having a higher attenuation coefficient (k) can suppress the amount of light entering the medium to a greater extent.

Therefore, in the present invention, a light amount reducing member is provided at an end side portion of a light guide plate, which is proximal to a linear light source (specifically, a joint portion of the end side and a broader side and portions neighboring the joint portion). The light amount reducing member is capable of transmitting light and is made of a material having a great attenuation coefficient. Therefore, the amount of light which is emitted from the linear light source through the light guide plate to the liquid crystal panel is suppressed. As a result, the occurrence of a bright line at a side of the liquid crystal panel, which is proximal to the linear light source, can be reduced. The light amount reducing member extends in the shape of an "L" at the end side portion of the light guide plate, which is proximal to the linear light source. The size of the light amount reducing member can be adjusted depending on the level of the bright line. For example, the light amount reducing member extends from a light inputting portion at the end side portion of the light guide plate, which is proximal to the linear light source, to a light emitting portion at the broad side of the light guide plate, which is proximal to the liquid crystal panel, resulting in an "L" shape. As a result,

the utilization efficiency of light is improved as compared to conventional techniques, such as covering a light source or a liquid crystal panel with an ITO film.

The light amount reducing member included in the backlight unit of the present invention may be made of a conductive material. By connecting the light amount reducing member of a conductive material to a ground, electromagnetic noise occurring at the linear light source (e.g., a fluorescent lamp) is absorbed by the light amount reducing member. As a result, an adverse influence of the electromagnetic noise on the liquid crystal panel can be reduced. The light amount reducing member is provided on a side of the light guide plate, which is proximal to the linear light source. Therefore, the adverse influence of the electromagnetic noise generated at the linear light source (e.g., a fluorescent lamp) on the liquid crystal panel can be prevented effectively as compared to conventional techniques using a reflection sheet comprising a conductive film, a metal lamp reflector, or the like.

For example, an ITO film which is a transparent conductive material is highly conductive because of its

low resistance. By connecting a light amount reducing member made of an ITO film to a ground, electromagnetic noise generated at the linear light source (e.g., a fluorescent lamp) can be absorbed by the light amount reducing member. As a result, the adverse influence of electromagnetic noise on the liquid crystal panel can be reduced. Although the ITO film is transparent, the light transmittance of the ITO film is about 70% to 90% with respect to the visible light region. Therefore, the amount of light emitted from the linear light source through the light guide plate to the liquid crystal panel is reduced, thereby reducing the occurrence of a bright line at a side of the liquid crystal panel, which is proximal to the linear light source.

Thus, the invention described herein makes possible the advantages of providing a backlight unit which can reduce the occurrence of a bright line at a side of a liquid crystal panel, which is proximal to a linear light source and electromagnetic noise occurring at the linear light source, while effectively utilizing light emitted by the linear light source; and a liquid crystal display apparatus comprising the backlight unit.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1** is a diagram showing a configuration of a major portion of a liquid crystal display apparatus **100** according to an embodiment of the present invention.

Figure **2** is a cross-sectional view showing one end portion of a backlight unit **10** of Figure **1**.

Figure **3** is a perspective view showing the end side portion of the backlight unit **10** of Figure **1**.

Figure **4** shows an exemplary development of a conductive sheet **23** of Figure **3**.

Figure **5** is a diagram showing exemplary performances of a general ITO film formed by an in-line type sputtering apparatus.

Figure **6** is a diagram showing an example of the behavior of light in a medium.

Figure **7** is a diagram showing the configuration of a major part of a conventional liquid crystal display apparatus **200**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be described by way of illustrative examples with reference to the accompanying drawings.

Figure **1** shows a configuration of a major portion of a liquid crystal display apparatus **100** according to an embodiment of the present invention.

The liquid crystal display apparatus **100** comprises a liquid crystal panel **101** used as a display screen and a backlight unit **10** provided at the rear side of the liquid crystal panel **101**. The backlight unit **10** irradiates the liquid crystal panel **101** with light.

The backlight unit **10** comprises a linear light

source **11**, a lamp reflector **12**, a chassis **13**, a reflection sheet **14**, a light guide plate **15**, a diffuse sheet **16**, a condenser sheet **17**, a diffuse sheet **18** having a light blocking function, and a light amount reducing member **21**.

The chassis **13** is in the shape of a frame made of, for example, a resin. The chassis **13** houses the plurality of members included in the backlight unit **10** and holds the liquid crystal panel **101**. One end portion of the chassis **13** is folded into a "U" shape (or a squared C shape). The linear light source **11** is housed within the folded portion (a concave portion of the folded portion). The linear light source **11** is a fluorescent lamp elongating in a direction or an LED. The lamp reflector **12** is provided between the folded portion of the chassis **13** and the linear light source **11**. The lamp reflector **12** is also in a "U" shape (or a squared C shape) so that the lamp reflector **12** surrounds the linear light source **11**. The lamp reflector **12** has an opening through which light emitted by the linear light source **11** goes out.

The reflection sheet **14** is provided on the chassis **13**. The light guide plate **15** is provided on the reflection sheet **14**. Further, optical sheets, such as the diffuse

sheet **16**, the condenser sheet **17**, the diffuse sheet **18** having a light blocking function, and the like, are provided on the light guide plate **15** in this order.

The light amount reducing member **21** is provided on a corner portion of the light guide plate **15**, which is proximal to the linear light source **11** (hereinafter referred to as the proximal corner portion of the light guide plate **15**). The proximal corner portion of the light guide plate **15** includes: a boundary between an end side of the light guide plate **15**, which is proximal to the linear light source **11**, and an upper, broader side of the light guide plate **15**, through which light is emitted; and portions neighboring the boundary. The light amount reducing member **21** is capable of transmitting light and has a greater attenuation coefficient than that of the light guide plate **15**.

The light guide plate **15** is in the shape of a wedge. The linear light source **11** is provided along one end side (left-hand end side) of the light guide plate **15**. Light emitted by the linear light source **11** is input to the end side (incident side) of the light guide plate **15**. Light input to the end side of the light guide plate **15** is

propagated through the light guide plate **15** toward the other end side. In this case, light going toward the rear side of the light guide plate **15**, on which the reflection sheet **14** is provided, is reflected by the reflection sheet **14** toward the front side of the light guide plate **15**, on which the liquid crystal panel **101** is provided. The light is emitted through the front side of the light guide plate **15**. A plurality of optical sheets (e.g., the diffuse sheet **16**, the condenser sheet **17**, and the diffuse sheet **18**) are provided at the rear side of the liquid crystal panel **101** so that the liquid crystal panel **101** is uniformly irradiated with light. Note that a lamp cover (not shown) is attached to a predetermined portion of the chassis **13**.

The liquid crystal panel **101**, on which a circuit board and the like are mounted, is provided on the backlight unit **10**. The liquid crystal panel **101** is fixed at a predetermined portion of the chassis **13** via a metal frame **20**.

Figure **2** is a cross-sectional view showing one end portion of the backlight unit **10** of Figure **1**.

The light amount reducing member **21** is provided

at an upper edge portion (corner portion) of an end side **15a** of the light guide plate **15**, which is proximal to the linear light source **11**. The light amount reducing member **21** is capable of transmitting light, has a greater attenuation coefficient than that of the light guide plate **15**, and has conductivity.

In the embodiment of the present invention, the light amount reducing member **21** extends from the end side **15a** to a light emitting side **15b** of the light guide plate **15**. The cross-section of the light amount reducing members **21** is in the shape of an "L".

Figure **3** is a perspective view showing the end side portion of the backlight unit **10**. A rubber holder **22** holds the linear light source **11**. A conductive sheet **23** is interposed between the rubber holder **22** and the light amount reducing members **21**. At least a portion of the conductive sheet **23** is attached to the metal lamp reflector **12** via a conductive adhesive. The lamp reflector **12** is connected (grounded) to GND.

Figure **4** shows an exemplary development of the conductive sheet **23**. The developed conductive sheet **23**

is in the shape of an "L". The right hand end side portion (**a**) of the developed conductive sheet **23** is connected (or adhered) to the light amount reducing member **21**, while the left hand end side portion (**b**) of the developed conductive sheet **23** is connected (or adhered) to the lamp reflector **12**. For example, the upper end side portion (portion **b**) of the developed conductive sheet **23** is connected to the lamp reflector **12** provided on the top side of the rubber holder **22**. Alternatively, the upper end side portion (portion **b**) of the developed conductive sheet **23** is interposed between the top side of the rubber holder **22** and the lamp reflector **12**.

The conductive sheet **23** is folded along dashed lines **A** and **B**.

The light amount reducing members **21** is made of a material which is capable of transmitting light, has a greater attenuation coefficient than that of the light guide plate **15**, and has conductivity. Examples of such a material include transparent conductive materials, such as ITO, zinc oxide, tin oxide, and the like. When the light amount reducing members **21** is made of such a material, the amount of light which is emitted from the linear light

source **11** to the liquid crystal panel **15**, is suppressed. Therefore, the occurrence of a bright line can be reduced on the linear light source **11** side of the liquid crystal panel **15**.

ITO is most preferable. This is because: (1) ITO has a low resistance and a high conductivity, i.e., is capable of readily absorbing electromagnetic noise, and (2) ITO is transparent but has a large attenuation coefficient, and has a light transmittance of about 70% to 90% in the visible light region.

A method of forming the light amount reducing member **21** (a thin film made of a transparent conductive material) includes sputtering, vapor deposition, a sol-gel technique, and the like. When the lamp reflector **12**, the light amount reducing member **21**, the light guide plate **15**, and the linear light source **11** are assembled (Figures **2** and **3**), the thickness of the light amount reducing member **21** is reduced as much as possible for an advantageous merit of structure design. Therefore, the light amount reducing member **21** made of a transparent conductive material (e.g., an ITO film) is preferably formed by sputtering or vapor deposition which can form a thin film. Sputtering is most

preferable.

Figure 5 shows exemplary performances of a general ITO film formed by an in-line type sputtering apparatus. In Figure 5, "transmittance" indicates the light transmittance of the ITO film irradiated with light (λ=550 nm); "heat-resistant resistance" indicates the resistance of the ITO film after holding at 300°C for 30 min; "etchability" indicates the time required to etch the ITO film with an etchant (H_2O:HCl:HNO_3=1:1:0.16) at 45°C; "alkali-resistance" indicates the rate of change in resistance before and after holding the ITO film in 1 wt% NaOH aqueous solution at 70°C for 20 min; "moisture resistance" indicates the rate of change in resistance before and after holding the ITO film in 90%RH at 60°C for 24 h.

As the thickness of the ITO film is decreased, the sheet resistance, heat-resistant resistance, and transmittance of the ITO film increase (Figure 5). Further, as the thickness of the ITO film is increased, the etchability of the ITO film decreases (Figure 5). Furthermore, changes in the alkali-resistance and moisture resistance of the ITO film are suppressed within ±10%.

irrespective of a change in the thickness of the ITO film (Figure **5**).

The size of the light amount reducing member **21** is determined depending on the arrangement of the linear light source **11** and the lamp reflector **12**. The thickness of the light amount reducing member **21** provided on the end side **15a** of the light guide plate **15** is preferably about one third of the thickness of the light guide plate **15** at the end side **15a** of the light guide plate **15**. The thickness of the light amount reducing member **21** provided on the light emitting side **15b** of the light guide plate **15** is preferably about 3 mm to 10 mm depending on the level of a bright line occurring at a side of the liquid crystal panel **101**, which is proximal to the linear light source **11**. The thickness of the light amount reducing member **21** is generally 25 nm to 250 nm, for example, when the light amount reducing member **21** is made of ITO film. The light transmittance of the light amount reducing member **21** varies more or less, depending on the thickness thereof.

As described above, in the backlight unit of the embodiment of the present invention, the light amount reducing member **21** is provided at the end side portion

of the light guide plate **15**, which is proximal to the linear light source **11** (specifically, a joint portion of the end side and the broader side and portions neighboring the joint portion). The light amount reducing member **21** is capable of transmitting light and is made of a material having a greater attenuation coefficient than that of the light guide plate **15**. Therefore, the amount of light which is emitted from the linear light source **11** through the light guide plate **15** to the liquid crystal panel **101** is suppressed. As a result, the occurrence of a bright line at the side of the liquid crystal panel **101**, which is proximal to the linear light source **11**, is reduced.

The light amount reducing member **21** may be made of a conductive material. By connecting the light amount reducing member **21** made of a conductive material via the conductive sheet **23** and the lamp reflector **12** to a ground, electromagnetic noise occurring from the linear light source **11** (e.g., a fluorescent lamp) is absorbed by the light amount reducing member **21**. As a result, the adverse influence of electromagnetic noise on the liquid crystal panel **101** can be reduced.

As described above, in a liquid crystal display

apparatus according to the present invention in which a backlight unit irradiates a liquid crystal panel with light for liquid crystal display, a light amount reducing member is provided at an end side portion of a light guide plate, which is proximal to a linear light source (specifically, a joint portion of the end side and the broader side and portions neighboring the joint portion). The light amount reducing member is capable of transmitting light and is made of a material having a greater attenuation coefficient than that of the light guide plate. Therefore, the amount of light which is emitted from the linear light source through the light guide plate to the liquid crystal panel is suppressed. As a result, the occurrence of a bright line at a side of the liquid crystal panel, which is proximal to the linear light source, can be reduced.

Further, by connecting a light amount reducing member made of a conductive material via a conductive sheet and a lamp reflector to a ground, electromagnetic noise occurring from the linear light source (e.g., a fluorescent lamp) is absorbed by the light amount reducing member. As a result, the adverse influence of electromagnetic noise on the liquid crystal panel can be reduced.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.